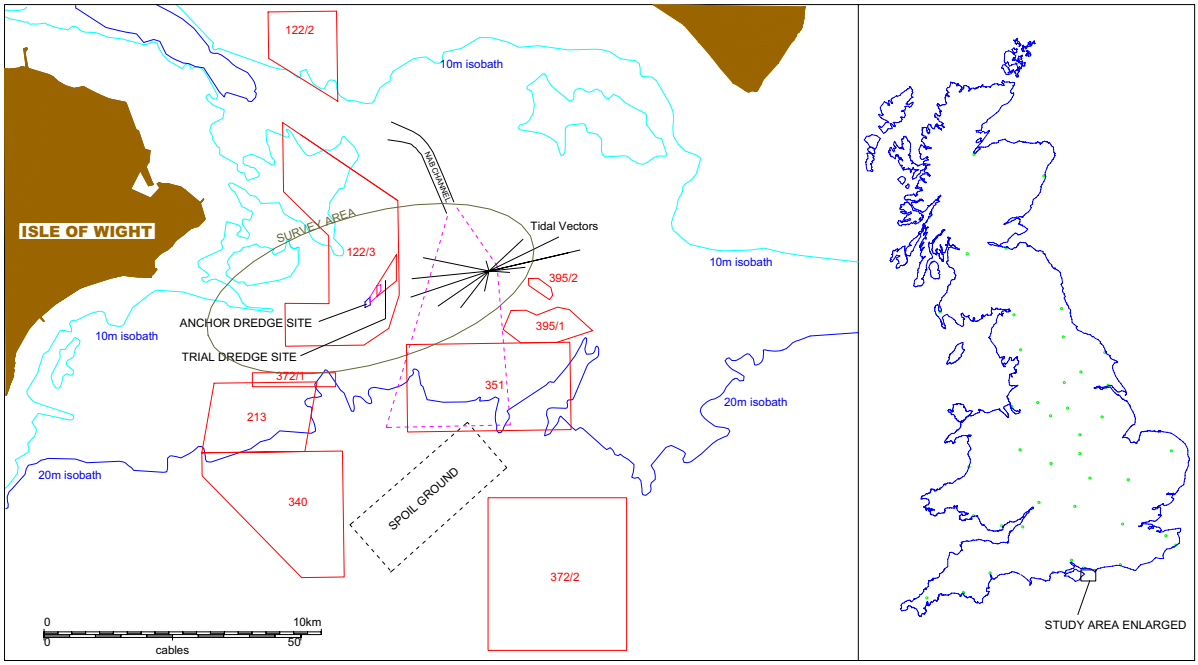
OCS STUDY
MMS 2000-054

INTEGRATED REPORT ON THE IMPACT OF MARINE AGGREGATE DREDGING ON PHYSICAL AND BIOLOGICAL RESOURCES OF THE SEABED

Final Report

October 2002



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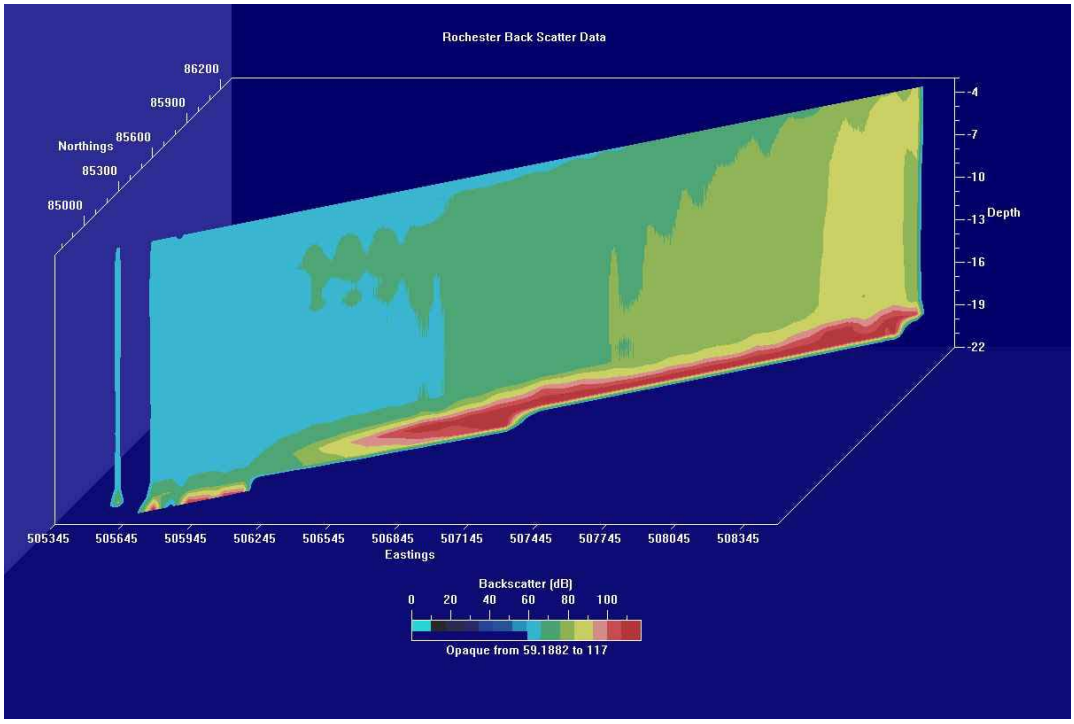

Coastline Surveys Limited
Bridgend Farmhouse
Downton Road
BRIDGEND
Gloucestershire GL10 2AX
UK

Tel: +44 (0) 1453 826772
Fax: +44 (0) 1453 826762
e-mail: info@coastlinesurveys.co.uk
www.coastlinesurveys.co.uk

D.R. Hitchcock B.Sc., Ph.D., M.R.I.C.S.

Marine Ecological Surveys Limited
Trewood Cottage
Steeple Lane
St.IVES
Cornwall TR26 2PF
UK

Tel: +44 (0) 1736 795975
Fax: +44 (0) 1736 793727
email: SEASURVEY@aol.com
www.marineecologicalsurveys.co.uk

R.C.Newell B.Sc., Ph.D., D.Sc.(Lond)
L.J.Seiderer B.Sc., Ph.D.

The United States Department of the Interior
Minerals Management Service,
381 Elden Street, Mail Stop 4030
Herndon, VA 20170-4817. USA.

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SPONSORSHIP

"This study was funded by the **Minerals Management** Service, U.S. Department of the Interior, Washington, D.C., under Contract Number 14-35-01-99-CT-30980. The study was supported by members of the UK British Marine Aggregate Producers Association, in particular United Marine Dredging Ltd"

CITATION

The correct citation for this report is:

Hitchcock, D.R., Newell, R.C., Seiderer, L.J. (2002) "Integrated Report on the Impact of Marine Aggregate Dredging on Physical and Biological Resources of the Sea Bed" U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Washington, D.C. **OCS Report Number 2000-054.**

ACKNOWLEDGEMENTS

This project was funded by the U.S. Department of the Interior (DOI), Minerals Management Service (MMS), International Activities and Marine Minerals Division (INTERMAR) under Contract #14-35-01-99-CT-30980. Mr. Barry S. Drucker was the MMS Contracting Officer's Technical Representative (COTR) and provided valuable assistance throughout the project. Mr. Wallace Adcox served as the MMS Contracting Officer. Dr. Andrew Bellamy and Mr. Simon Luckett of United Marine Dredging provided important data and logistical support with licence details and facilities aboard the dredger.

Drs. Richard Newell and Lindsey Seiderer authored sections on the biological investigation and resources and expanded their authoritative appraisal of the biological impacts of marine aggregate dredging. Mr. Steve Bell provided sterling support with developing the imaging and visualisation techniques for the plume morphology. Mr. James Robinson, Ms. Nicola Simpson, Ms Nicola Stearn, Ms. S. Newell, Mr. Shaun Galliver, Mr. Peter Woods and Mr. Andrew Hermiston all provided laboratory and field assistance. Mrs. M. Hitchcock undertook the pre-press review.

Dr. David Hitchcock served as Principal Investigator and Author of the report and I am indebted to the assistance of those above and others not mentioned.

QUALITY STATEMENT.

Field surveys were carried out by Dr. D. R. Hitchcock B.Sc., Ph.D. (Wales), Dr. R.C. Newell B.Sc., Ph.D., D.Sc. (London), Dr. L.J. Seiderer B.Sc., Ph.D. (Cape Town), Mr. J.E. Robinson B.Sc. and Mr. S. Galliver B.Sc. Dr. Hitchcock holds United Kingdom status as a Chartered Surveyor. Separation and faunal identification was carried out by Mr. J.E. Robinson B.Sc., Ms. N.M. Stearn B.Sc., Ms. N. Simpson B.Sc., MSc. and Ms. S.C. Newell of Marine Ecological Surveys Limited. Ms. N.M. Stearn holds a Natural History Museum Id.Q. qualification in marine macrofaunal identification. Dr. L.J. Seiderer carried out community analysis.

Coastline Surveys Limited possesses corporate registration as a company of Chartered Hydrographic Surveyors according to the charter of the United Kingdom Royal Institute of Chartered Surveyors. Marine Ecological Surveys Limited is a member of the Environmental Law Foundation. Dr. R.C. Newell is an accredited Environmental Auditor certificated with the Institute of Environmental Assessment and Management for Environmental Impact Assessments to BS7750 under Eco-Audit Regulations (Registrant Number 9E).

Revision Number	Date	Comments	Issued	Approved
Issue 0	December 2001	Draft for comments	*Hitchcock*	*Drucker*
Issue 1	November 2002	Final for Issue	*Hitchcock*	*Drucker*

ABSTRACT

An integrated study of the impacts of dredging on the physical and biological resources of a non-screened dredge area on the South Coast of Britain has been completed. This site has been dredged since 1991 by anchored suction dredgers and occasionally (since late 1998) by trailing suction dredgers, removing a total of nearly 2 million tonnes over that period. The gravelly resource has been extracted from a very small target area of roughly 400m x 400m, within a larger licence.

Over 350km of high-resolution sidescan sonar mapping has confirmed the areas that have been dredged by observing the extent of small pits formed on the seabed. 177 seabed samples have been obtained and the majority analysed for sedimentary and faunal analysis. The study area extended up to 10km either side of the dredge zone (one tidal excursion) in order to identify far-field effects on both physical and biological resources of the seabed.

The results clearly show that the physical impact of dredging on the seabed (without screening) is limited to a zone within approximately 300m downtide of the dredge area. There is no visible evidence of suspended sediments falling to the seabed beyond this zone, which may be manifested as infilling of small pits by fine sediments, siltation within crevices or development of migratory sand ripples. That is not to say that such events cannot happen, but probably merely represents a poor supply of fine material due to the lack of screening activities. However there is some statistical evidence that the surface sediment samples have a greater sand fraction within the excursion track of the plume than those samples either side.

The biological “footprint” of impact has been established. Species diversity, population density and biomass of benthic macrofauna of the study site is typical of that recorded in UK waters. Average benthic macrofauna biomass as a whole is equivalent to 4.06 grams Carbon per m^2.

The studies show that dredging at anchor using a small, modern 2300 tonne suction dredger is associated with a reduction of species diversity of 66%, population density (87%) and biomass (80-90%) of benthic invertebrates. Very importantly, the deposits are loaded as an 'all-in' cargo with no discharge of screened material at this site. In this case the suppression of invertebrate species variety, population density and biomass appears confined to the dredge sites themselves, with no evidence of impact outside the boundaries of the dredge pit.

Some distance outside the dredge site, there is evidence of an enhancement of benthic diversity and biomass in an elongated 'halo', which extends for a distance of up to 3 km from the dredge site. Average benthic macrofauna biomass is equivalent to 17 grams Carbon per m^2, some 4 times greater than the surrounding deposits.

Our monitoring aboard the dredge vessel determined some 17.36 tonnes ash-free dry weight of organic matter may be released per year in the outwash of dredgers operating within the restricted worked site of the much larger North Nab licence. This material is likely to be carried beyond the boundaries of the Licence Area along the axis of the tidal excursion. Whether this is sufficient to account for the enhanced values of biomass 1-3km from the dredge site is unknown.

In contrast with the intensively anchor dredged site, the trailer dredged site has been less exploited. Communities within this site are largely similar to those in the surrounding deposits. This suggests that the processes of recolonisation and recovery are sufficient to keep pace with the rate of removal of biomass when trailer dredging here. It must be noted that the key factor here may be *intensity* rather than *method* of dredging used.

Sites which have been left undredged for known times suggests that initial recolonisation by mobile components of the benthos can occur within weeks with some 70-80% of the species variety returning. This process is often accompanied by a similarly rapid increase in population density, although not as frequently, but with both of these stages in the recolonisation sequence being substantially completed within 3-6 months after cessation of dredging.

Restoration of biomass is achieved by growth of the small individuals that recolonise the deposits. This stage is incomplete even after 18 months compared with areas some distance away from the dredge site, and this finding is in keeping with anecdotal information available from the literature.

The results for trailer-dredged studies elsewhere indicate that species diversity may initially recover much quicker, as mentioned above. Population density is not dissimilar to anchor dredge sites, with biomass recovering to within 80% of the undredged sites within 3 months.

We conclude with the following general hypothesis based on this study and another partial study recently completed in the Southern North Sea on a trailer dredge study site (Newell *et al* 2002):-

(1) The degree of suppression of the fauna in the dredge site itself is clearly dependent on the intensity of dredging. In high intensity dredging (North Nab) the suppression of population density, species variety and biomass can be as high as 60-80%. In areas that are dredged less intensively by trailer techniques, the suppression is either less than at anchor dredge areas (North Nab), or undetectable (North Sea).

(2) There is no evidence of an impact outside the immediate dredge sites.

(3) Both sites show some evidence of an enhanced biomass and population density at some distance from the dredge site, possibly reflecting the deposition of organic components from fragmented invertebrates discharged in the outwash.

(4) Recovery of population density and species variety can be very rapid indeed. This depends on the degree of disturbance to which the area is subjected under natural conditions. In shallow water wave disturbed areas such as the North Sea, colonising species are mobile and well adapted to rapid recolonisation. In more stable (equilibrium) communities such as occur on coarse rocks and cobbles, recolonisation is slower.

(5) Recovery of biomass is achieved by growth of the recolonising individuals. In this case restoration of biomass generally requires at least several years. In some of the deeper water communities that we have recently analysed, individual species may be at least 20 years old. This implies that deep-water stable equilibrium communities may require a time of at least 20 years for recovery, compared with 2-3 years in shallow water coastal sands.

(6) Anchor dredging has a significant impact on the species variety, population density and biomass of benthic macrofauna, although without screening is largely limited to within a hundred metres of the active dredged zone. Trailer dredging, on the other hand, appears to have a much lesser impact on species variety, population density and biomass, although this may be limited to the lower intensity of trailer dredging activities in the study areas. However, species recovery data suggests that recovery is quicker for trailer dredge areas, due to the reduced distance of 'inwalk' for colonising species (only the widths of trailer tracks), compared with the larger disturbance of an anchor dredged area.

(7) On the available evidence collected herein, we propose that trailer dredging over a wide area at an intensity carefully matched to the potential times for species recovery (indicated by the response times to natural disturbances e.g. turbulent shallow water or less disturbed deeper waters) will be more sustainable than intensively dredging small areas of seabed.

(8) Re-analysis of ADCP backscatter data collected in 1995 on a screened dredge site some 20km east of the Nab study license supports recent evidence for development of a near-bed benthic boundary plume some 2-4 metres thick and a few tens of metres wide which extends beyond the limits of the dredge activity. On an extraction license undertaking cargo screening, this near bed plume may exceed 4.5 kilometres downtide. Such a phenomenon provides a potential mechanism for impacting physical and benthic resources well beyond the dredge licence boundary and requires further investigation.

Importantly, the detailed analyses of these and other data for this project have revealed the susceptibility of analysis methods to 'noise' within the datasets. This is caused by inter-sample variability due to significant under sampling of the diverse benthic macrofauna of sands and gravels by conventional methods.

We have shown that single samples of macrofauna obtained from a Standard 0.2m^2 'Hamon' type grab contain sufficient taxa to use non-parametric multivariate analytical techniques to define community composition. Values for individual variables, such as species variety are, however, heavily dependent on the number of replicate samples taken. At least 3 replicate samples are required to obtain a satisfactory assessment of the species composition of the macrobenthos of sands and muds, but that 13 or more replicates are required for gravels. The repercussions of this in terms of scale, frequency, density of sampling sites, numbers of replicate samples, alternative grab sizes and subsequent cost implications must be carefully considered when designing suitable monitoring protocols.

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LIST OF ACRONYMS

ABP	Acoustic Backscatter Profiling
ADCP	Acoustic Doppler Current Profiling
AFDW	Ash Free Dry Weight
AGC	Automatic Gain Control
ARCS	Admiralty Raster Chart Service
BMAP	Backscatter Mapping program (CSL in-house ADCP profiling software)
BMAPA	British Marine Aggregate Producers Association
CBP	Continuous Backscatter Profiling
CEFAS	The Centre for Environment, Fisheries and Aquaculture Science
CSL	Coastline Surveys Limited
DGPS	Differential Global Positioning System
DRP	Dredging Research Program
GPS	Global Positioning System
IALA	International Association of Lighthouse Authorities
ICES	International Council for the Exploration of the Sea
INTERMAR	Office of International Activities and Marine Minerals Division
LAT	Lowest Astronomical Tide
MDS	Multi-Dimensional Scaling
MESL	Marine Ecological Surveys Limited
MMS	Minerals Management Service
MVBS	Mean Volume Backscattering Strength
OCS	Outer Continental Shelf
OSGB36	Ordnance Survey of Great Britain 1936 (datum)
PLUMES	PLUme MEasurement System (USACE)
SPM	Suspended Particulate Matter
SSC	Suspended Solids Concentration
UKHO	United Kingdom Hydrographic Office
UMD	United Marine Dredging Ltd
USACE	United States Army Corps of Engineers
VMADCP	Vessel Mounted Acoustic Doppler Current Profiling
VMAP	Velocity Mapping (CSL in-house ADCP profiling software)
WGS84	World Geodetic Survey 1984

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Appendix Table 2. Listing of the benthic samples taken at the North Nab study site in 1999-2001, using a 0.2m^2 Hamon Grab. Positions are shown reference to OSGB36 (in metres). Particle size distribution figures are % passing particular sieve sizes (125.0mm – 10.0mm this table).

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Appendix Table 3. Table summarising he species of macrofauna (>1mm) extracted from the sediments of the North Nab study site in 1999.

Appendix Table 4. Table summarising the variety and abundance of the macrofauna (>1 mm) extracted from the sediments of the North Nab Study site in 1999. The species identification codes are shown in parentheses and are followed by the number of individuals per Hamon Grab sampler of sediment (0.2m^2). Also shown are the total number of individuals (abundance) and species (variety) recorded at each sampling station. Note that P1 denotes a small colonial organism, whilst P2 denotes a large colonial organism. These colonial data were included in the multivariate analysis as P1 = 1 and P2 = 10.

Appendix Table 5. Table summarising the biomass results for macrofauna (>1mm) extracted from the sediments of the North Nab Study site in 1999. Data have been calculated as Ash-Free Dry Weight (AFDW) from the blotted wet weight using conversion factors from Eleftheriou and Basford (1989). Values are expressed as grams AFDW per 0.2m^2 Hamon Grab sample.

Appendix Table 6. Table summarising the shell length data for *Crepidula fornicata*. The numbers of specimens occurring in each size class are shown for each station in which the slipper limpet occurred, together with the total number in each station, and the percentage of the total in each size class.

Appendix Table 7. Table summarising the shell length (mm) for *Crepidula fornicata* as a function of age, assessed from growth bands

Appendix Table 8. Table summarising the total number of individuals of *Crepidula fornicata* at each of the survey stations at which the slipper limpet was found. Also shown are the number of year 1 (<20 mm) individuals, the equivalent biomass (g wet weight) and the ash free dry weight (g AFDW) calculated from wet weight x 0.085 (*from* Eleftheriou and Basford 1989).

Appendix Table 9. Table summarising the cumulative numbers of species discovered, the number of new species, the numbers of individuals and the total number of species recorded in a series of sand and mud samples of 0.2 m^2 taken in and adjacent to the North Nab Study site during March 1999. The species identification codes are shown in parentheses.

Appendix Table 10. Table summarising the cumulative numbers of species discovered, the number of new species, the numbers of individuals and the total number of species recorded in a series of coarse gravel samples of 0.2 m^2 taken in and adjacent to the North Nab Study site during March 1999. The species identification codes are shown in parentheses.

Appendix Table 11. Table summarising the cumulative numbers of species discovered, the number of new species, the numbers of individuals and the total number of species recorded in a series of gravel samples of 0.2 m^2 taken in and adjacent to the North Nab Study site during March 1999. The species identification codes are shown in parentheses.